Issued October 16, 1907.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS—MILTON WHITNEY, Chief.

SOIL SURVEY OF THE CROOKSTON AREA, MINNESOTA.

BY

A. W. MANGUM AND F. C. SCHROEDER.

[Advance Sheets—Field Operations of the Bureau of Soils, 1906.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the Congressional district or districts in which the survey is made and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., November 13, 1906.

SIR: In compliance with a request from Mr. George A. Ralph, State drainage engineer, transmitted to this Bureau and indorsed by the Hon. H. Steenerson, a soil survey of the Crookston area, Minnesota, was made during the summer of 1906 to determine the agricultural value of certain lands which it is proposed to drain. I transmit herewith the report on the results of this survey and recommend its publication as advance sheets of the Field Operations of the Bureau of Soils for 1906, as provided by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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MAP.

Soil map, Crookston sheet, Minnesota.

SOIL SURVEY OF THE CROOKSTON AREA, MINNESOTA.

By A. W. MANGUM and F. C. SCHROEDER.

DESCRIPTION OF THE AREA.

The area surveyed is located in the northwestern part of the State of Minnesota, and consists of 23 townships situated in the western part of Polk County. A few of the western tier of townships, which border on the Red River of the North, are irregular in size and con-

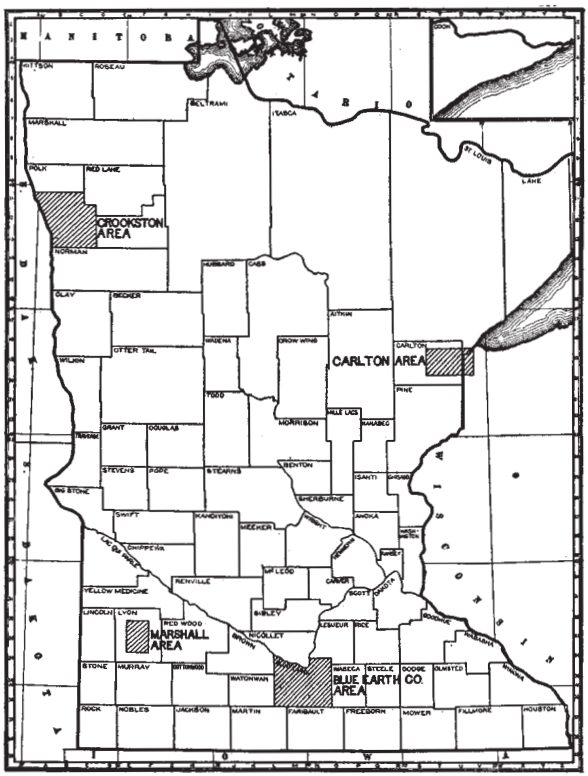

FIG. 1.—Sketch map showing location of the Crookston Area, Minnesota.

tain more or less than 36 square miles. The total area of the townships embraced by the survey is 498,688 acres, or about 779 square miles.

The area is bounded on the north by Red Lake County and a part of Polk County, on the east by Red Lake County and a part of

Polk County, on the south by Norman County, and on the west by the Red River of the North, which forms the boundary line between the States of Minnesota and North Dakota.

The area lies wholly within the region once covered by the waters of glacial Lake Agassiz. The principal topographic features consist of the broad, level valley of the old lake basin and the series of narrow ridges or beaches that mark the various stages of the ancient lake as it slowly receded toward the north. The basin has a general slope toward the northwest. Its surface has the general appearance of a perfectly level plain, but numerous shallow basins, gentle swells, small coulées,[a] and other slight depressions give the whole a very gently undulating topography. Several ancient stream channels, once occupied by the Red Lake River, are found along this stream, but owing to the level topography very little erosion has taken place along the smaller streams or coulées.

The old beach lines, which occur in the eastern part of the area, consist of narrow ridges, varying from a few rods to about one-half mile in width and extending in a general north and south direction. These beaches are all more or less similar in size and general features. Their western slope is often steep and abrupt, while they usually slope gently toward the level interbeach areas to the eastward. The oldest beach within the area extends for a short distance along the southeastern boundary line, and the crest of this ridge, which has an elevation of more than 1,100 feet above sea level, is the highest point in the area. There are also a few kamelike knolls and sand dunes in the southeastern corner of the area which have an elevation of about 1,100 feet. The lowest point is in the extreme northwestern corner, at the junction of the Red Lake River and the Red River, the elevation here being about 807 feet above sea level.

The Red Lake River is the principal stream of Polk County and receives the drainage water from almost every part of the area surveyed. This stream enters the area from the northeast, in Gentilly Township, and flows in a general southwesterly direction to a point about 4 miles east of Crookston; thence it follows a general northwesterly course until it joins the Red River in the extreme northwest corner of the area. The course of this stream through the level country which borders it is very winding and crooked, but it has cut its channel to a depth of 15 feet or more below the level of the lands bordering it, and there is seldom more than a very narrow strip of overflow land along its immediate banks. There is usually a second terrace a short distance from the present channel of the stream, which rises 15 feet or more to the level of the old lake basin.

The Sand Hill River, which crosses the southern part of the area

[a] The word "coulée" is here used as locally applied.

in a general east and west direction, drains a large proportion of the southern tier of townships. At one time this river, on reaching Scandia Township, became lost in a large swampy area which covered a considerable proportion of several townships. A large drainage canal, constructed through this swampy area, now serves as the channel of the river until it reaches Hubbard Township. There the canal connects with the natural outlet of the old swamp basin, and the river follows this channel in a northwesterly direction, emptying into the Red River near Climax, in Vineland Township. The Grand Marais Slough, now occupying a former channel of the Red Lake River, begins near the village of Fisher, in Fisher Township, and follows a general northwesterly course, leaving the area in section 5, Huntsville Township, and emptying into the Red River some distance north of the area. The old river channel affords good natural drainage to the lands bordering it and also serves as an outlet for a number of large drainage ditches. The drainage waters of the entire area ultimately reach the Red River of the North, which forms the western boundary of the area.

The settlement of the area began early in the decade 1870–1880. A few white men had taken up lands in the river valley at an earlier date, but it was not until the railroad reached the area in about 1872 that the real settlement of the county began. Among the early settlers were many Swedes and Norwegians, who came in from the older settlements in Minnesota or from the more eastern States. Many other settlers of the same nationality soon followed these, so that a large proportion of the present population of the area consists of Scandinavians. A number of French, German, and Canadian farmers are also found in the area.

With the exception of the townships of Kertsonville and Parnell and the swampy area in Scandia Township, the area is comparatively thickly settled, and a large percentage of the farming land is continuously under cultivation. The sparse settlement and lack of agricultural development in the localities mentioned above are mainly due to the poorly drained condition of the farming lands. As a whole, the area has been settled by an intelligent class of farmers, who are at present in a very prosperous condition.

There are two cities and several small towns in the area. Crookston, the county seat of Polk County, and the largest city, is situated near the center of the area and has a population of about 8,000. East Grand Forks, with a population of about 3,000, is situated in the extreme northwestern part of the area. Fisher, Climax, and Beltrami are all towns of from 300 to 500 inhabitants, and are important local shipping points for the country surrounding them.

The transportation facilities of the area are excellent. Crookston, the most important railroad center and shipping point, is connected with St. Paul, Duluth, and Winnipeg, Canada, and all points west by important branches of the Great Northern railroad system. A branch line of considerable local importance, extending from Crookston to Fargo, N. Dak., crosses the southwestern part of the area; a branch of the Northern Pacific railroad system, extending from Winnipeg, Canada, to St. Paul, Minn., traverses the area, passing through Crookston and East Grand Forks, and also a local branch line of this railroad, connecting East Grand Forks and Red Lake Falls, extends along the northern boundary of the area surveyed. All but five of the twenty-three townships included in the survey are crossed by one or the other of these railroads, and small stations are located at frequent intervals along the lines, where from one to four elevators have been constructed for the storing of the grain which is to be shipped to the larger markets.

Crookston, East Grand Forks, and Grand Forks, N. Dak., are the principal local markets for all the products of the area. The wheat not sold to the local mills is first sold to the buyers at the elevators and is later shipped to the larger eastern markets. The barley not marketed at the local feed mills and breweries is shipped to Minneapolis. The production of oats seldom exceeds the local demand, but a small quantity is usually marketed in the northeastern part of the State. All the rye produced is sold on the local markets. The entire flax crop is usually sold to the oil mills at Minneapolis. The cattle are generally sold on the local markets, but a small number are annually shipped to St. Paul. A large amount of hay is produced in the area, and there is usually a demand for this product on the local markets at Crookston or at Grand Forks, N. Dak., but a small amount is shipped to the lumbering districts of northern Minnesota.

The area is located within easy reach of the larger markets of Minnesota, as well as those situated in the States farther east, and the railroad facilities for marketing the products are exceptionally good.

CLIMATE.

The climate of the area is subhumid, the normal annual rainfall being 22.55 inches. The greater part of the rainfall usually occurs in the late spring and early summer, a time when of most benefit to crops grown on well-drained land. However, the large amount of precipitation in May, June, and July frequently causes the poorly drained sections of the area to remain in a condition too wet for cultivation until too late in the season for any crops to be matured on them.

The winters are cold, the temperature sometimes falling to 30° F. or more below zero, but during the coldest months, January and Feb-

ruary, the records show that the monthly precipitation is less than 1 inch, and hence the extreme cold is not so noticeable as it would be in a region of greater humidity. The following table, taken from the records of the Weather Bureau, shows the normal monthly and annual temperature and precipitation as observed at Crookston, and represents fairly well the climatic conditions over the entire area:

Normal monthly and annual temperature and precipitation.

Month.	Crookston.		Month.	Crookston.	
	Temperature.	Precipitation.		Temperature.	Precipitation.
	°F.	In.		°F.	In.
January	3.1	0.49	August	65.5	3.16
February	5.4	.82	September	55.7	2.10
March	20.2	1.12	October	44.1	1.97
April	42.8	1.94	November	24.5	.61
May	54.6	2.77	December	11.8	.35
June	64.3	3.77			
July	68.2	3.45	Year	38.4	22.55

The following table, compiled from the same source, gives the dates of the last killing frost in the spring and the first in the fall during the period 1897–1904, and shows the average length of the growing season to be about four months:

Dates of first and last killing frosts.

Year.	Crookston.		Year.	Crookston.	
	Last in spring.	First in fall.		Last in spring.	First in fall.
1897	June 7	Sept. 17	1902	May 9	Sept. 11
1898	May 11	Sept. 9	1903	May 29	Sept. 16
1899	May 14	Sept. 25	1904	Apr. 20	Sept. 21
1900	May 9	Sept. 17	Average	May 17	Sept. 17
1901	June 7	Sept. 18			

AGRICULTURE.

Most of the early settlers of the area took up claims or bought land along the banks of the Red and Red Lake rivers, largely because of the better drainage and superior shipping facilities in this part of the area. The hitherto unbroken prairie was plowed up and sown to wheat, which was the only crop grown, with the exception of a small acreage of oats and barley used to feed the horses kept on the farm. As the soil was naturally very productive, wheat was continuously grown year after year without careful preparation of the soil or any rotation of crops.

Before sowing in the spring the surface of the soil was usually pulverized to some extent with a harrow, although in may instances when time was lacking the wheat was sown on the plowed land without harrowing. The crops were harvested with a binder. The wild grasses were entirely depended upon for hay and pasture for the stock. In later years the production of oats, barley, and flax increased. Particularly during the last few years, flax, which is a late spring crop, has been grown more extensively to replace the shortage in the acreage usually devoted to wheat. Land plowed in the spring produces a crop of flax quite free from weeds. The acreage devoted to macaroni wheat has steadily increased since its introduction a few years ago, because it gives uniformly better yields than the varieties commonly grown. Rye and buckwheat are grown to a small extent on the sandy types of soil. Timothy is grown successfully on all the soils under cultivation. The greater proportion of the crop is cut for hay, but some seed is produced for the local market. The acreage devoted to tame grasses is steadily increasing, though as in the early days wild hay is annually produced in large quantities. Hemp is grown to some extent in the vicinity of Crookston and East Grand Forks. A local factory extracts the fiber or tow, which is used for the manufacture of rope and commands good prices in eastern markets. Garden truck of good quality is grown in the vicinity of the larger cities in quantities sufficient only to supply the local demand.

Most of the land intended for grain crops is usually plowed during the summer and fall months, but if the season is excessively wet the plowing must be done in the spring. Land plowed in the fall generally produces better yields, due perhaps to the action of frost upon the soil and to the fact that the organic matter plowed under has had more time to become thoroughly decomposed. The depth of plowing, which varies from 3 to 6 inches, depends largely upon the depth of the surface soil. In places where the surface soil is shallow care is taken not to turn up any of the subsoil, as in some types it is very hard to cultivate and reduces the crop yields for several seasons. When most of the plowing must be done in the spring before seeding the acreage of grain sown is very much reduced, as it is impossible both to plow the land and sow the seed on the large acreage usually devoted to grain in the time ordinarily required for seeding only. A gang plow, requiring four to six horses, is commonly used. Several attempts at using a powerful traction engine with a gang of eight plows have been made in the area, but proved impracticable because the fields become too soft after heavy rains. Various types of modern harrows are used to pulverize the surface of the plowed land before drilling in the seed. The preparation of the land for seeding is generally hurried, and not as thorough as that

practiced in the older, more thickly settled parts of the State. The modern seed drill is the only one now in use, it being of such width that one man under favorable conditions can sow from 20 to 30 acres a day.

Timothy is usually sowed with wheat, which serves as a nurse crop for the young plants. It has been the general opinion that clover could not grow successfully in the area, but experiments have proved that it thrives on well-drained land.

The adaptation of the different soil types to particular crops is not generally recognized. Wheat, oats, barley, and flax are the crops generally grown on all the soils in the area, but buckwheat and rye are grown only on the sandy types. The poorly drained portions of the farms are usually reserved for hay fields and pasture. Very little attention has been given to a systematic rotation of crops, and no commercial fertilizer and but very little manure is applied to the soils. The kind of crops grown depends entirely upon the character of the spring season. When field work can be done early in the spring, a large acreage of wheat is sown, but if the season is late, oats, barley, and flax are grown more extensively. Occasionally a portion of the farm is devoted to timothy for two or three years. It is a general practice on the sandy soil types to give a field a season of rest after it has produced several successive crops of grain. This is done to restore the soil to its former state of productiveness, which would be unnecessary if a systematic rotation of crops was practiced and a more general use made of barnyard manure. A large proportion of the manure, which has accumulated for years around the barns, is at present allowed to go to waste.

Weeds, especially wild oats, mustard, wild sunflower, Canada thistle, and kinghead, are becoming very bothersome where their presence has been ignored, and fields are occasionally so badly infested that the grain when thrashed is fit for feed only.

A large percentage of the crops are thrashed from the shock, but some farmers, to guard against possible loss from excessive rains, stack the grain. Straw is commonly used as fuel for the thrashing engines, and most of the remainder is usually burned in the field, because there is not enough live stock kept on the farms to convert it into manure.

Dairying is still in its infancy in the area, but several creameries and a cheese factory are kept in full operation from early spring until late in the fall by the patronage of farmers living in their vicinities.

The markets of Crookston and East Grand Forks are supplied with milk and cream from dairy farms located near these cities. During seasons when the crop yields were very light the income from

dairy products has in many instances been sufficient to pay the running expenses of the farm.

Cattle have been raised to some extent for beef, but the low price paid for them in the past has been a discouragement to stockmen, who have not made a practice of finishing their stock by grain feeding before putting them on the market, as is done in some other beef-raising districts.

The supply of farm labor is usually sufficient to meet the demand except during the harvesting season. On the smaller farms the plowing and spring seeding are done by the farmer and his family. The use of modern farm machinery has helped very materially to increase the amount of work done by one man in a day, and the simple construction of the machinery makes it possible for a boy of from 12 to 15 years of age to operate it with ease.

Some of the laborers on the large grain farms and the hired help on the dairy and stock farms are men who reside in or near the area. They are usually paid $25 a month or $1 a day, with board and lodging. The haying and harvesting season annually attracts thousands of transient laborers from the States to the east and south. On account of their roving disposition and lack of interest, these men can not be relied upon to give perfect satisfaction, but many farmers are compelled to hire them or lose their crops. The harvesters usually get from $1.75 to $2.50 a day, with board and lodging. In seasons of exceptionally poor crops, or when there is a plentiful supply of labor, as low as 75 cents a day has been given, but at times when harvesters are in great demand as high as $3 a day has been paid. When the crops are ready to harvest the available labor must be hired regardless of cost, for delay will mean a great loss of grain by its shelling in the field.

The United States census of 1900 gives the average size of the farms in Polk County as 224 acres. Many are much larger than this, and others consist of only 40 to 160 acres. About 70 per cent of the farms are cultivated by the owners, and the remainder are rented on shares or for cash. When rented on shares, if the owner provides the working stock, seed, and farm machinery, and pays half of the thrashing bill, he receives from two-thirds to three-fourths of the crop. If he gives half of the seed used and pays half of the thrashing bill, he gets half of the crop produced.

The highly improved land in the vicinity of the cities and towns is valued at $35 to $50 an acre, while that in the more remote localities is held at $20 to $35. For partly improved land prices vary from $20 to $35 an acre, depending upon location, soil type, and extent of improvements made, such as buildings, fences, and drainage. The poorly drained tracts between the beaches and the swampy land in the southern part of the area are valued at $15 to $20 an acre.

A systematic rotation of crops, better preparation of the soil before sowing, more careful selection of seed, and a more thorough system of drainage on each individual farm are suggested to secure better and more uniform crop yields. A greater diversification of crops grown and the use of barnyard manure on the sandy and well-drained soils would greatly improve the agricultural conditions of the area.

SOILS.

No outcrops of bed rock occur in the area surveyed. The various types of soil are derived from modified glacial drift, which was deposited in the basin and along the beaches of glacial Lake Agassiz, or from material deposited by the rivers over the level lake basins after the lake had receded and before the rivers had cut their present channels.

The more recent alluvial deposits are not easily distinguished from the finer material deposited in the deep, quiet waters of the lake, but a large proportion of the fine laminated silt and clay that form the soils of the western part of the area is thought by geologists to have been deposited by the rivers. The clay belt, with an average width of about 15 miles, extends across the western part of the area in a general north and south direction. The thickness of this formation in the vicinity of the Red River has been estimated at from 60 to 100 feet, but it gradually becomes thinner toward the east, and in the vicinity of the old beach lines the underlying glacial till is encountered nearer the surface.

The light soils of the eastern part of the area owe their origin to the deposition of the coarser material along the shores of Lake Agassiz. The coarse sand and gravel was accumulated along the beaches by the action of the waves, while the finer sand particles were deposited in the shallow waters and now form the soils occupying the level areas just west of the old beach lines. A large sandy area in the southwestern corner of the survey was formed as a delta at the mouth of the Sand Hill River when that stream emptied into Lake Agassiz at this point. The sand has been drifted and formed into low, rounded dunes and ridges by the action of the wind.

The small stones and bowlders found on the surface of the low, poorly drained areas that occupy the broad, level depressions between the old beaches were probably deposited along the shores of the ancient lake by floating ice during the glacial period. As the ice sheet moved northward the waters of the glacial lake slowly receded, and the series of ridges, bowldery flats, and level sandy plains which occur in the eastern part of the area were formed at each temporary halt of the glacier.

The western part of the area was probably in a swampy condition and subject to frequent overflow by the rivers for a long period after

the waters of Lake Agassiz had retreated northward, but as the rivers eroded their present channels and the regional drainage became better established the swampy area gradually decreased.

The large proportion of organic matter which the soils of this section of the area contain is probably due to the decomposition of the vegetable matter accumulated during this swampy period. The swampy stage in the process of the formation of the soil is found at present in the large poorly drained area in Scandia Township. A large proportion of this marshy area has been partially drained, but the underlying clay is still too soft and too thoroughly saturated with water for the land to be of any agricultural value. Thorough drainage, however, transforms these marshy areas into the productive black silty clay which occupies a large proportion of the area surveyed. In the low depressions near the center of this large poorly drained area the lack of drainage and the slow decomposition of the vegetable matter, under swampy conditions, has given rise to a deposit of Peat which covers an area of several square miles.

The entire western two-thirds of the area is occupied by the heavier types of soil, composed of silt and clay. A heavy black silty clay occurs over a very large proportion of this section, but as the northwestern corner of the area is approached the amount of silt in the subsoil gradually increases and the sticky, silty clay finally grades into a subsoil of a more silty texture.

The most extensive poorly drained area occurs in the southwestern part of the survey and is known as the Beltrami Swamp, but several other smaller bodies too wet for cultivation occupy depressions in other localities embraced by the survey. During the last ten years, however, the construction of drainage canals has greatly decreased the acreage of marshy land in every poorly drained section of the area.

The level and gently undulating sections, lying between the old beach lines on the east and the belt of silt and clay on the west, are occupied by fine sandy loam soils. Near the old beaches occur small areas of fine sandy loam underlain by gravel, and usually in a condition too wet for agricultural purposes.

A series of narrow ridges of sand and gravel extends across the eastern one-third of the area in a general north and south direction. Between the larger ridges the soil is usually a loam or heavy sandy loam. This land is poorly drained and a number of small bowlders are usually found on the surface or in the soil.

The soils of the area surveyed vary in texture from heavy silty clay to light incoherent sand. They have been separated into eight distinct types, the separation being based on the texture of the soil and subsoil to a depth of 3 feet. When the agricultural value of a soil is materially influenced by lack of drainage, deep accumulations

of organic matter, or by any other local conditions, the areas thus affected have either been classified as a distinct type where such a separation was warranted or have been indicated on the accompanying soil map by means of a symbol and described as phases of the types of which they are a part.

The texture of the first 10 or 12 inches of two distinct types of soil may be very similar, as in the case of two of the lighter soils mapped in the area, but the wide difference in their agricultural value or in the texture of their subsoils may cause them to be classed as separate types. The separation of two of the heavier types of soil is also based mainly on the texture of the deeper subsoil. Under one occurs a silty loam, which causes it to be more easily drained. The other has a heavier clay subsoil, enabling it to conserve more moisture and better to resist drought. The large amount of coarse sand and gravel found in the soil which occurs on the old beaches of glacial Lake Agassiz causes this soil to have a coarser texture than the sandy type which occupies the low, rounded dunes and ridges in the extreme southeastern part of the area.

The soil mapped as Fargo silt loam is similar to the soil which occurs just across the river in the Grand Forks, North Dakota, area, and the Fargo gravelly loam of the same area has many of the characteristics of the Benoit loam of the present area.

The Sioux gravelly sandy loam is similar in texture and agricultural value to the old beach deposits mapped in the adjoining areas and in the Owosso and Saginaw areas, Michigan, and the Peat can probably be correlated with the deposits of partially decomposed organic matter which occupy poorly drained depressions in many of the glaciated areas surveyed. The soils of the Crookston area are productive, and when well drained and properly cultivated will produce very profitable yields of all crops suited to the climatic conditions of the area.

The names and extent of the several types are given in the following table:

Areas of different soils.

Soils.	Acres.	Per cent.	Soils.	Acres.	Per cent.
Fargo clay loam	320,640	64.3	Peat	8,256	1.6
Fargo fine sandy loam	85,632	17.2	McLeod sand	4,288	.9
Benoit loam	31,360	6.3	Benoit fine sandy loam	4,032	.8
Sioux gravelly sandy loam	24,448	4.9	Total	498,688	
Fargo silt loam	20,032	4.0			

FARGO CLAY LOAM.

The surface soil of the Fargo clay loam is very uniform in color and texture in every section of the area where it occurs. The soil, to

an average depth of 12 to 15 inches, consists of a dark-brown to black silty clay that contains a very large percentage of organic matter. This material becomes slightly heavier as the depth increases and grades at about 12 inches into a heavy drab to gray silty clay, with a very finely stratified structure.

Silty layers are often encountered at various depths in the heavy subsoil, and the lower portion of a 3-foot section sometimes has a more silty texture than the material found immediately below the surface soil. When exposed to the air this subsoil becomes lighter in color and on drying forms hard, whitish, bricklike clods which show very clearly the stratified structure and are very difficult to pulverize.

The relatively large quantity of organic matter in this soil renders it loamy, friable, and easily cultivated when in a dry, well-drained condition, but when wet it is sticky and tenacious, clods badly, and does not scour well, making plowing almost impossible. The heaviest phase of the type occupies the low, poorly drained depressions, locally known as "gumbo lands," which are usually flooded or in a cold, wet condition during the greater part of the growing season. This phase is soggy and unproductive, but when well drained and thoroughly cultivated the surface becomes as loamy and friable as that of typical areas.

A large area of the Fargo clay loam located in the southwestern part of the survey is at present too wet for cultivation. This area was until recent years subject to annual overflow from the Sand Hill River and remained in a marshy, partially flooded condition during the entire spring and summer, but the construction of drainage canals has partially reclaimed it, and small tracts are gradually being more thoroughly drained and utilized for agricultural purposes. The level of the underground water is very near the surface in the poorly drained areas, and both the soil and subsoil are so soft and saturated with water during the greater part of the season that they will not support the weight of a team. The marshy phase of the type, however, is covered by a heavy growth of native grasses and in the latter part of the summer where the land has dried out to sufficient extent the grass is cut and stacked for hay.

When this marshy land is well drained it soon becomes valuable for agricultural purposes, and areas reclaimed within the last ten years can not be distinguished from those which have been successfully cultivated for a much longer period. The extent of this poorly drained phase of the Fargo clay loam has been indicated on the accompanying soil map by means of a symbol.

Along the boundary between this type of soil and the Fargo silt loam the percentage of silt in the subsoil is greater than is usually found in the typical gray to drab silty clay subsoil. The heavy clay

subsoil of the Fargo clay loam gradually grades into the silty loam which underlies the Fargo silt loam and the change is so gradual that no distinct boundary between the two soils exists.

The Fargo clay loam occupies a large proportion of the entire western half of the area, extending in one unbroken belt from the northern to the southern boundary of the survey, and embracing the greater part of twelve townships. Other areas of less extent occur in every township included in the area, with the exception of Liberty. The areas have the general appearance of being almost level, but low, gentle swells and shallow depressions give them a very gently undulating topography. Shallow sloughs and coulées, occupying narrow winding channels, are frequently encountered in many localities.

As a whole the natural drainage of this type is very poor. The narrow strips of land bordering the larger streams and coulées are usually fairly well drained, but artificial drainage is necessary on the greater proportion of the level areas, in order to obtain profitable yields from the crops grown. However, the drainage of this soil has been greatly improved during recent years by the construction of large ditches through almost every poorly drained locality.

The Fargo clay loam is derived from deposits of silt and clay which occupy the lower basin of glacial Lake Agassiz. A part of this material was probably laid down in the deep, still waters of the lake, but the lacustrine deposits over a large part of the western half of the area have been covered by a deep alluvial deposit of more recent date. After the waters of the lake had receded, the rivers which traverse this section of the area frequently overflowed the lower portion of the old lake basin, and the silt and clay from which a large proportion of this type is derived are thought to have been deposited by these streams at such times.

The organic matter, of which there is a relatively large proportion in this soil, owes its origin to the swampy and poorly drained conditions that have existed in this section since the recession of the lake. During the earlier part of that period, at least, the entire area embraced by the Fargo clay loam was probably in a condition very similar to that now found in the large marshy areas in Scandia Township.

Small accumulations of alkali occur in limited areas of this soil, usually in places in need of more thorough drainage. Better drainage and the use of tile would soon free these small areas from excessive amounts of soluble salts.

When well drained, the Fargo clay loam is the most valuable soil in the area for general farming purposes. In seasons of average rainfall very profitable yields are obtained from all the crops grown in the area, but during wet seasons the yields are often small, especially on the poorly drained areas. Wheat during the last three

seasons (1903 to 1906) has averaged only 10 or 12 bushels per acre, though in a favorable season an average yield of 18 to 20 bushels per acre has been secured. Oats average about 40 bushels, but 50 bushels per acre has often been produced on well-drained land in a favorable season. The average yield of barley lies between 25 and 30 bushels per acre. This crop is usually sown late in the season, in years when the soil has remained in a condition too wet for cultivation until too late for the wheat crop to be sown and matured. If the growing of barley received the care and attention usually given in the cultivation of wheat and oats, the yields would be larger. Flax usually yields from 10 to 15 bushels per acre. Macaroni wheat is now grown to a limited extent, with yields ranging from 18 to 20 bushels per acre.

A few vegetables are produced for the local markets with good results, and hemp has been successfully grown on some of the better drained areas. Timothy is grown to some extent and averages about 1½ tons of hay per acre. When thrashed for seed it yields about 8 bushels per acre. Limited experiments with clover and alfalfa have demonstrated that they can be successfully grown on this type of soil.

The average results of mechanical analyses of samples of the Fargo clay loam are given in the following table:

Mechanical analyses of Fargo clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
14846, 15820	Soil	0.0	2.4	0.8	4.9	14.8	50.1	26.6
14847, 15821	Subsoil	.0	.7	.4	2.6	14.1	47.9	34.0

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$); No. 14846, 10.38 per cent; No. 14847, 28.74 per cent; No. 15820, 18.13 per cent; No. 15821, 28.34 per cent.

FARGO FINE SANDY LOAM.

The soil of the Fargo fine sandy loam, to an average depth of about 12 inches, consists of a fine to very fine sandy loam of a dark-brown to black color. When dry the sand content of the soil is more noticeable and the surface often has a dark-gray appearance, but when wet or in poorly drained depressions the high organic matter content gives it the general characteristics of soils of heavier texture. The soil contains enough silt and clay to render it under certain moisture conditions slightly sticky, and the surface of some of the small, poorly drained depressions becomes slightly baked and sun-cracked.

The subsoil to a depth of 25 inches is a gray to brown, sticky, fine sandy loam, usually containing a larger percentage of silt than the soil, and grading at an average depth of 25 inches into a fine yellow to gray sand, which is often stained with iron and sometimes contains small, partially decomposed iron concretions. In the spring and early summer this deep layer of fine sand is usually so thoroughly saturated with water as to resemble quicksand.

The Fargo fine sandy loam is easily cultivated, and can be plowed much earlier in the spring and sooner after heavy rains than the heavier types of soil. The clods formed when the soil is plowed in a wet condition do not become hard and the surface is easily reduced to a state of good tilth. This type of soil occupies a large proportion of the east-central part of the area, which lies between the narrow sand ridges or old beaches on the east and the broad belt of silt and clay on the west. It occurs in large irregular-shaped areas which extend in a general north and south direction and embrace the greater parts of Crookston, Gentilly, and Reis townships. It also occupies areas of considerable extent in Liberty, Russia, Onstad, Fairfax, Kertsonville, and Lowell townships.

The position of the Fargo fine sandy loam in the old lake basin is slightly higher than that occupied by the Fargo clay loam, and the soil in general is better drained. The topography is comparatively level, but low, narrow elevations extending in a general north and south direction across the larger areas and the shallow, basinlike depressions occurring at frequent intervals cause the surface of the type as a whole to be gently undulating.

The Fargo fine sandy loam, owing to the sandy texture of both soil and subsoil, is naturally better drained than the heavier type of soil occupying the level and gently undulating sections of the old lake basin, and the crops grown on it are not so seriously damaged during a season of heavy rainfall. In the spring and early summer, however, the level of the ground water is seldom more than 3 feet below the surface of the more level areas, and some of the shallow depressions frequently remain in a cold, wet condition for a considerable length of time, though the excess water drains off more rapidly than where the subsoil is heavier, permitting the soil to warm up earlier than is the case of types having this characteristic. The soil occupying the lower ridges is fairly well drained. More drainage ditches and the use of tile on the low-lying areas of the type would greatly enhance the agricultural value of the land.

The fine sand and silt from which this soil is derived is a lacustrine deposit laid down in the shallow waters near the shore of glacial Lake Agassiz. These areas bordering the clay belt often

contain a slightly larger proportion of very fine sand and silt than those nearer the old beaches, as the finer material was deposited in the deeper water at a greater distance from the shores, while the coarser sand particles were washed up by the waves and laid down in the rough water nearer the beaches. The low ridges that occur in the large areas were probably formed by wave action in the same manner as small sand bars are formed to-day near the shores of the larger lakes.

Slight accumulations of alkali sometimes occur in poorly drained areas of this type, but their very limited extent and infrequent occurrence make them of little or no importance.

Under present conditions there is more certainty of securing a profitable yield from the crops grown on the Fargo fine sandy loam than on any other soil type in the area, with the possible exception of the Fargo silt loam, whose agricultural value is not easily affected by either a wet or a dry season. Wheat yields on an average 10 to 12 bushels per acre, but 15 to 18 bushels are frequently secured. Macaroni wheat averages from year to year 18 or 20 bushels per acre, but larger yields are secured during a favorable season. The yield of oats ordinarily ranges from 30 to 35 bushels, but 40 to 50 bushels per acre have frequently been obtained. Barley produces 18 or 20 bushels, and during a favorable season 25 bushels per acre. The average yield of flax is about 12 bushels per acre. Timothy is mainly grown for hay and averages 1½ tons per acre. Vegetables, which do well, are produced to a limited extent for the local markets. No rye or winter wheat is grown on this soil.

The average results of mechanical analyses of this type of soil are shown in the following table:

Mechanical analyses of Fargo fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
14848, 14850, 15816, 15818.....	Soil	0.2	1.8	0.9	22.4	47.9	20.2	6.5
14849, 14851, 15817, 15819.....	Subsoil.....	.2	.8	.8	23.7	56.0	9.7	8.3

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 14848, 8.89 per cent; No. 14849, 23.35 per cent; No. 15816, 9.22 per cent; No. 15817, 15.48 per cent; No. 15818, 11.17 per cent; No. 15819, 13.26 per cent.

SIOUX GRAVELLY SANDY LOAM.

The soil of the Sioux gravelly sandy loam consists of about 12 inches of a dark-brown to black loamy sand or light sandy loam,

containing a few small gravel and a considerable amount of organic matter. The sand content is made up of all grades, from fine to coarse sand or small gravel, but the medium to fine grades usually predominate.

This soil grades into a subsoil composed of layers of gravel and coarse sand, which often occur in strata of fairly uniform thickness. The gravel particles vary in size from coarse sand to small cobbles several inches in diameter, and the interstitial material consists of various grades of sand. The stratified structure of these deposits of sand and gravel is plainly shown in cuts and excavations, but in some localities the strata are so closely related that the whole resembles a mass of rounded, waterworn gravel embedded in a coarse sand matrix. The gravel content of the surface soil is not high enough to interfere with cultivation, and with the exception of a few bowlders sometimes found near the foot of some of the steeper slopes of the ridges both the soil and subsoil are free from large rock fragments.

The Sioux gravelly sandy loam occurs in the eastern part of the area surveyed and occupies narrow ridges which extend across the area in a general north and south direction. A few areas consist of a series of narrow ridges, not more than a few rods wide, which are separated by small, poorly drained depressions. The summits of the larger ridges are almost level, with the slopes to the east usually gradual and to the west more abrupt and often too steep to permit of cultivation. The largest ridge of sand and gravel extends across the area from the northern to southern boundary, and smaller ridges branch off from this at frequent intervals. Other small gravelly ridges are frequently encountered, running parallel to the larger ones, and separated from them by shallow, poorly drained basins occupied by a heavier type of soil.

Owing to the porous nature of both soil and subsoil, the Sioux gravelly sandy loam is excessively drained. The water which falls on the soil rapidly seeps through the coarse sand and gravel of the subsoil and is drained into the shallow depressions which occur along the base of the ridges. When there is an unusual amount of rainfall during the spring and early summer the crops grown on this soil make very profitable yields, but during a dry season they are usually seriously damaged by drought.

The gravelly ridges occupied by the Sioux gravelly sandy loam were formed by the action of the waves of glacial Lake Agassiz, the coarse sand and gravel being washed up by the waves and deposited along the shores, forming the narrow ridges or beaches which mark the various stages in the recession of the lake. The small isolated

gravelly area which occurs in the lower basin of the old lake at a distance from the old beach lines is probably of glacial origin.

The crop yields vary considerably, according to the amount of rainfall during the growing season. Estimates by farmers cultivating this soil place the average yields in seasons of normal rainfall as follows: Wheat, 10 bushels; oats, 25 to 30 bushels; flax, 8 to 10 bushels; barley, about 18 bushels, and rye, about 12 bushels per acre. Smaller yields than these are obtained when the precipitation is unusually light, and much heavier yields are frequently secured when there is an unusually large amount of rainfall during the growing season.

The average results of mechanical analyses of the fine earth of this soil are given in the following table:

Mechanical analyses of Sioux gravelly sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
15812, 15814	Soil	4.9	28.6	14.3	22.2	5.0	17.9	7.3
15813, 15815	Subsoil	11.3	44.8	22.9	13.7	1.2	4.1	1.9

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$); No. 15813, 7.17 per cent; No. 15815, 9.81 per cent.

BENOIT LOAM.

The soil of the Benoit loam, to an average depth of 12 inches, is a dark-brown to black loam or heavy sandy loam containing a considerable proportion of organic matter. Small bowlders are frequently encountered on the surface or embedded in the soil, but they do not occur in sufficient numbers to give the soil the characteristics of a stony loam or to interfere seriously with its cultivation. The upper portion of the subsoil, 12 to 25 inches, consists of a gray to drab heavy gritty loam, containing gravel, coarse sand particles, and small bowlders. This, in turn, is underlain by a heavy gray to drab silty clay, in which a few small bowlders also occur. Pockets of coarse sand and gravel are frequently found at various depths in the 3-foot section, but the underlying clay is usually encountered at a depth of 30 to 36 inches.

Large areas of the Benoit loam occur throughout the eastern tier of townships embraced by the survey. The most important unbroken area occupies a large proportion of the eastern parts of Onstad and Kertsonville, and areas of less extent are found in Parnell, Fanny, Liberty, and Gentilly townships.

This type occupies the broad, shallow depressions and flat, poorly drained areas that occur principally between the narrow sand ridges or beach lines and occasionally along the western base of the last or inner beach of the old glacial lake. The surface of these shallow basins is almost level, but there is usually a gentle slope toward the center. Low, rounded elevations or slight ridges occasionally occur in the larger areas, and shallow sloughs or small marshy depressions are encountered at frequent intervals. The natural drainage of the Benoit loam is very poor. The water from the surrounding country drains into these low depressions, and a very large proportion of the whole type is at present in a condition unfit for cultivation. The position and topography of the soil makes drainage very difficult, and artificial drainage is not practiced to any extent on the larger areas.

The soil is formed from glacial material redeposited by the waters of glacial Lake Agassiz. A small proportion of the sand content has probably been washed down from the neighboring sand ridges, but the greater part of the finer material was deposited in these basins while they were occupied by the waters of the lake. The small bowlders found in both the soil and subsoil were probably deposited from floating ice washed upon the beaches of the lake. The small accumulations of alkali frequently encountered are the result of the continual evaporation of water which collects in the poorly drained depressions.

A very small percentage of the Benoit loam is cultivated. The type supports a heavy growth of native grasses, which are cut for hay. A few of the better drained areas are cultivated and produce very fair yields during seasons of average rainfall, but at present the soil as a whole is so poorly drained that it is used mainly for pasture land or hay meadows. The limited acreage cultivated seems best adapted to oats and flax, the former producing about 30 bushels and the latter from 10 to 15 bushels per acre. Barley on the better drained areas produces about 20 bushels, but a yield of 25 bushels per acre has often been secured in a favorable season. Very little wheat is grown on this soil, as it usually remains in a wet condition until too late in the spring for this crop to be sown and matured, but the better drained areas have produced yields of 12 to 15 bushels per acre.

Insufficient drainage is the main difficulty in the cultivation of the Benoit loam. The wet and partially flooded condition of the greater proportion of the type during a wet season or after heavy rains makes it of small agricultural value. With thorough drainage it would be a valuable soil for general farming purposes.

The following table gives the average results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Benoit loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
15826, 15828	Soil	1.3	7.8	6.6	21.1	14.0	28.7	20.7
15827, 15829	Subsoil	2.3	8.9	5.8	17.1	11.6	25.9	27.9

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 15826, 9.31 per cent; No. 15827, 29.56 per cent; No. 15828, 12.21 per cent; No. 15829, 23.43 per cent.

M'LEOD SAND.

The McLeod sand is a light-brown to gray, medium to fine sand, with an average depth of 12 inches and usually containing enough organic matter to cause the surface to be slightly loamy. This is underlain by a light-brown to yellow sand of about the same texture as the soil, which extends to a considerable depth.

The type occurs in one relatively small area, located in Liberty Township in the extreme southeastern corner of the area surveyed. Its topographic features consist of low, rounded dunes and ridges, scattered over a comparatively level sandy plain. Some of the rounded dunes just outside of the area surveyed reach a height of 30 feet or more above the more gently rolling areas surrounding them, but those within the survey are lower and the topography is more gently rolling. This topography, together with the sandy, porous character of the soil, causes the type to be excessively drained, and except in seasons of unusual rainfall the crops suffer to a considerable extent from droughts.

The sand composing this type was first deposited as a delta of the Sand Hill River when that stream emptied into Lake Agassiz, and after the waters of the lake had receded this material was formed into low mounds and ridges by the action of the wind. Some of the larger sand dunes are of very little agricultural value, but the more level areas often produce very good yields during a wet season. This soil can be cultivated early in the spring, even in wet seasons, and is best adapted to early maturing crops. When there is a large rainfall during the growing season, the more level areas produce from 12 to 18 bushels of wheat per acre, but in a season of average rainfall the yield is seldom more than 8 or 10 bushels per acre. In a favorable season the yield of oats is 30 to 38 bushels, of barley about 18 bushels, and of flax about 10 bushels per acre. Each of these crops, however, frequently suffers from drought and all give much lighter

yields in a season of average rainfall. Vegetables, grown to a limited extent for local markets, do fairly well.

Methods which will aid in the conservation of the soil moisture, such as shallow plowing and shallow cultivation after rains, should be practiced in the cultivation of this soil. No systematic rotation of crops is followed at present and no commercial fertilizer and very little manure is used.

The results of mechanical analyses of a sample of this soil are given in the following table:

Mechanical analyses of McLeod sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
15830	Soil	0.8	9.2	20.4	55.9	2.0	7.4	4.5
15831	Subsoil	.1	7.3	21.0	62.4	2.9	3.2	3.4

BENOIT FINE SANDY LOAM.

The soil of the Benoit fine sandy loam is a black to dark-brown fine sandy loam, with an average depth of 12 to 15 inches. The soil contains a relatively large quantity of organic matter, and a few small bowlders are sometimes encountered scattered at intervals over the surface. This surface material grades into a subsoil consisting of a gray to yellow sandy loam, becoming lighter in texture as the depth increases, until at 25 to 30 inches it is a yellow to gray fine sand, containing gravel and small cobbles. This subsoil is underlain by beds of gravel, which usually occur at a depth of 30 to 36 inches, but are sometimes encountered nearer the surface. The surface soil is very similar to that of the Fargo fine sandy loam, but its topographical position, natural drainage, and gravelly subsoil make it of much lower agricultural value.

The Benoit fine sandy loam occurs in the northeastern part of the area surveyed. The largest area is found in the central and north-central parts of Parnell Township, and an area of smaller extent occurs in the northeastern sections of Fanny Township. It occupies low, basinlike depressions which occur between or adjacent to small ridges of the Sioux gravelly sandy loam.

The topographic features consist of numerous small, shallow depressions and gentle swells, which causes the surface of the type as a whole to be gently undulating. These areas receive the drainage water from the surrounding lands and are naturally very poorly drained. Water collects in the shallow depressions during the early spring or after heavy rains, and a large proportion of the type re-

mains in a wet, partially flooded condition during the greater part of the spring season. The numerous swales and depressions occurring within the areas embraced by this type, together with its topographic position, make artificial drainage very difficult.

The soil owes its origin to glacial drift which has been modified by the action of the waters of glacial Lake Agassiz. A part of the fine sand in the surface soil has probably been washed down from the sandy ridges and from the areas of Fargo fine sandy loam bordering these broad depressions, but the greater part of the fine sand and gravel was deposited along the shores of the old lake.

At present less than 1 per cent of the Benoit fine sandy loam is under cultivation, the greater proportion being used for hay meadows and as pasture land. Some of the better-drained areas occupying slight elevations have been cultivated to a limited extent and produce fair yields during a favorable season. The better-drained areas are not productive during a dry season, and during a wet season the greater part of the type is too wet and poorly drained to be of much agricultural value.

The following table shows the results of mechanical analyses of this type of soil:

Mechanical analyses of Benoit fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
15838	Soil	0.1	5.7	11.0	27.5	33.0	13.4	9.7
15839	Subsoil	.6	7.4	11.1	27.4	29.1	19.1	5.2

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 15838, 4.36 per cent.

FARGO SILT LOAM.

The surface soil of the Fargo silt loam is a black to dark-brown silty loam or clay loam, with an average depth of 12 to 15 inches. The upper layer of the soil contains a large quantity of decomposed organic matter, but as the depth increases the proportion of such material decreases and the soil becomes slightly lighter in color. The soil grades at about 15 inches into a yellow silty loam which sometimes becomes a gray or slightly mottled silty clay at a depth of 3 to 5 feet below the surface. The soil is easily cultivated and breaks up into a loamy, friable condition, the silty texture, together with the large proportion of organic matter present, giving it a very desirable tilth.

The Fargo silt loam occurs in one large, unbroken area in the extreme northwestern part of the area surveyed. It occupies the whole

of Rhinehart and a large part of Huntsville Township and also extends a short distance into Bygland Township. The topography is almost level, but an occasional slight depression or gentle swell causes the surface of the type as a whole to be very gently undulating. The natural drainage afforded by the Red River of the North, Red Lake River, the Grand Marais Slough, and numerous small coulées causes this soil to be better drained than any other type found in the lower parts of the old lake basin. Artificial drainage, though not practiced to any extent, would increase the value of the land during wet seasons.

The Fargo silt loam owes its origin to the weathering of the alluvial deposits laid down in the lower basin of Lake Agassiz by the overflow of the Red River of the North and the Red Lake River. During a considerable period after the glacial lake had receded these streams must have overflowed the lower part of the old basin, depositing over the older lacustrine material the silt and clay held in suspension. Owing to the naturally good drainage of the type alkali has accumulated nowhere in sufficient amounts to be injurious to crops.

Almost all of the Fargo silt loam is continuously under cultivation, and it is classed as one of the most productive soils in the area surveyed. Wheat yields from 15 to 20 bushels per acre, and oats average 35 to 40 bushels, though as much as 50 to 60 bushels of oats per acre has been obtained in favorable seasons. Barley gives average yields ranging from 20 to 25 bushels, and flax 12 to 15 bushels per acre. Vegetables and garden truck are grown on this soil with excellent results. Timothy is grown to a limited extent both for hay and seed and does exceedingly well.

The average results of mechanical analyses of samples of this type of soil are given in the following table:

Mechanical analyses of Fargo silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
15834, 15836	Soil	0.0	0.1	0.5	2.5	3.1	72.2	20.9
15835, 15837	Subsoil	.0	.1	.1	.7	1.7	79.1	17.8

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 15834, 7.99 per cent; No. 15835, 32.23 per cent; No. 15836, 17.75 per cent.

PEAT.

The Peat consists of 1 to 3 feet or more of fibrous, partially decomposed, organic matter of a brown color, underlain by a gray to drab silty clay, which is usually so thoroughly saturated with water that it is in a soft, pasty condition. The Peat area embraces about 13 square miles in Scandia Township, in the southern part

of the survey. It occupies the lower basin of the large marshy area found in that section of the county, and is the result of the slow decomposition of organic matter under swampy conditions.

During the spring months the Peat area is usually flooded and standing water is often encountered at a slight depth below the surface during the remaining months of the year. A large drainage canal traverses this area, and much of the land could be easily drained by small lateral ditches leading to the main outlet and thus be made valuable for agricultural purposes. The Peat supports a heavy growth of native grasses and is at present utilized mainly as pasture land.

DRAINAGE.

The most important requisite for the agricultural development of the area is the extension of the drainage systems, until they are adequate for the removal of the water which in spring and early summer collects in the depressions and floods the level and poorly drained areas in every locality embraced by the survey. Under the present systems areas of considerable extent often remain too wet for cultivation until so late in the season that grain can not be sown and harvested, and over a large proportion of the flat or gently undulating sections the soils are usually too cold and too thoroughly saturated with water during the early part of the season for the best results to be obtained from the crops grown on them. During the last ten years much progress has been made in the drainage of the area, and extensive tracts of land once unfit for agricultural purposes have been reclaimed and are now classed among the most valuable agricultural lands in the county.

Several large drainage canals, with outlets into the principal stream courses or large coulées, have been constructed through the extensive, poorly drained districts, and the excess water from the neighboring lands is carried to the main canals by means of shallow lateral ditches which extend along many of the section lines. These laterals are usually too shallow to drain thoroughly the lands bordering them, for depressions or swales lower than the level of these ditches sometimes occur in the neighboring fields.

Very few farmers in the area have made any attempt to improve the drainage of their lands by the construction of smaller drains or ditches leading from the poorly drained areas on their farms to the principal canals or laterals.

Tile drainage has not yet been attempted in the area, but a system is now being installed on the State experimental farm near Crookston to demonstrate the advantages to be derived from the use of tile. Underdrainage will undoubtedly greatly improve all the heavier types of soil and will be beneficial to the better-drained land, as well

as to that which remains in a cold, wet condition during the greater part of the spring and summer. The use of tile will make the soil more friable, cause it to warm up earlier in the spring, permit earlier cultivation, aid in carrying off the excess water at times of heavy rains, and by lowering the water table will increase the capacity of the subsoil for absorbing and retaining water for the future use of the growing crop. It will also diminish or prevent the damage done to crops by the water standing on the cultivated fields after heavy rains.

The importance of establishing a thorough system of drainage in all sections of the area can not be overestimated. The influence of drainage on the agricultural value of the soils is clearly demonstrated during a wet season, when the soils occupying the sandy ridges produce yields equal to or better than those obtained from the heavier types, which in ordinary seasons are the most productive soils in the area.

ALKALI.

In small areas, seldom more than a few square rods in extent, which occur in various parts of the survey, sufficient alkali is found in the soils to be harmful to crops. An analysis of some of the alkali crusts of this area shows that the salts consist mainly of magnesium sulphate. The accumulations are directly due to poor drainage, and occur in slight, shallow depressions where the drainage waters from the surrounding lands collect and evaporate or, more commonly, on the low elevations or ridges which are surrounded by areas of poor drainage. The alkali is not often apparent during the early spring months or during a wet season, for the reason that it is dissolved by the rain water and carried from the surface or the upper soil to the deeper subsoil, but during the hot, dry summer months when capillary action is continuous and evaporation rapid the alkali is again brought up and deposited on the surface.

Alkali is more frequently encountered in the heavy clayey types than in the light sandy soils, but it is sometimes found in the fine sandy loam areas where the drainage conditions have been especially favorable for its accumulation. If underdrainage were practiced in these areas, the alkali, which is dissolved by the heavy rains, would be carried off through the drains and the soils would soon be freed from harmful accumulations of the soluble salts.

SUMMARY.

The area surveyed is located in Polk County, in the northwestern part of the State of Minnesota, within the basin of glacial Lake Agassiz. The surface varies from almost level to undulating and ridgy.

The Red River of the North, which forms the western boundary, and the Red Lake River, which traverses the area, are the principal streams. The Sand Hill River and the Grand Marais Slough are streams of considerable importance in the local drainage. Artificial drainage is necessary over a very large proportion of the area.

The better drained sections are comparatively thickly settled. Many of the early settlers came from the Eastern States or from Canada, but a very large percentage of the present population are Scandinavians. Crookston and East Grand Forks, the principal cities, are located on the Great Northern and Northern Pacific railroads, which afford ample facilities for transporting the products of the area to all the larger markets.

The climate is subhumid, the normal annual precipitation being 22.55 inches. The largest amount of rainfall occurs in May, June, July, and August. The average length of the growing season is about four months.

Wheat was the first crop grown and is still the principal product. Barley, oats, and flax are also important. Corn is grown for feed purposes on the dairy farms, and some of the early maturing varieties produce a fair quality of seed. Timothy is grown for both hay and seed. Experiments have shown that alfalfa and clover can be grown on the better drained areas. Hemp has been grown on a small acreage of the Fargo clay loam, and rye and buckwheat are sometimes produced on the sandy types of soil. Vegetables and garden truck are produced successfully for the local markets.

Most of the plowing is done in the fall, and land plowed at this season usually produces better yields than that plowed in the spring. Modern farm machinery is in general use in this area, enabling the farmers to cultivate a large acreage with a minimum amount of hired help. Labor is usually plentiful except in the harvest season, when there is always a great demand for farm laborers at prices ranging from $1 to $3 a day, with board.

No commercial fertilizer and very little manure is applied to the soils, and no systematic rotation of crops is practiced. About 70 per cent of the farmers own the land they cultivate, and the remainder rent land on shares or for cash. The value of farming lands varies. The better drained areas of the Fargo clay loam and Fargo silt loam, situated near the local markets, are valued at $50 to $60 an acre, but the average price of these types throughout the area is about $25 to $35 an acre. Some of the sandy lands and land of all types poorly drained are valued at less than $20 an acre.

The soils are derived from reworked glacial material deposited in glacial Lake Agassiz and from silt and clay deposited by the river after Lake Agassiz had receded northward.

The Fargo clay loam, a black silty clay or clay loam underlain by a gray to drab silty clay, is the most extensive and one of the most productive soils. Where well drained, very profitable yields of wheat, oats, barley, and flax are secured. Hemp, vegetables, and garden truck are also grown. The poorly drained areas produce much wild hay. Artificial drainage is necessary on the more level areas. Wheat, oats, barley, and flax are the principal crops.

The Fargo silt loam is naturally well drained and one of the most productive of the soils. Very profitable yields of wheat, oats, barley, flax, and timothy are usually secured. A very large percentage of this type is continuously under cultivation.

The Benoit loam is very poorly drained, and drainage is difficult. It is used mainly for hay or pasture land. The small areas drained and under cultivation produce fair yields of oats, barley, and flax.

The McLeod sand occupies a small area in the southeastern part of Liberty Township. The more level parts produce fair yields during wet seasons, but the crops suffer from droughts during seasons of even average rainfall.

The Benoit fine sandy loam occupies low depressions, is poorly drained, and is at present of low agricultural value.

The Sioux gravelly sandy loam occupies narrow ridges in the eastern part of the area, is excessively drained, and the crops are often seriously damaged by drought. During a wet season, however, very profitable yields of the general crops of the region are secured.

A large deposit of Peat occurs in Scandia Township. This area is at present very poorly drained and is used only as pasture land.

Drainage is the most important factor in the development of the entire area surveyed. Many large drainage canals have been constructed in various parts of the area during the last ten years, and the number is annually increasing. Tile drainage is not practiced in the area at the present time, but a system of underdrainage is at present being established on the State experimental farm near Crookston to demonstrate the advantages to be derived from the use of this system.

Small accumulations of alkali occur in every poorly drained locality in the area. These alkali spots, which are the result of poor drainage and which will disappear when the condition is remedied, are not of sufficient extent and importance to warrant the construction of an alkali map.

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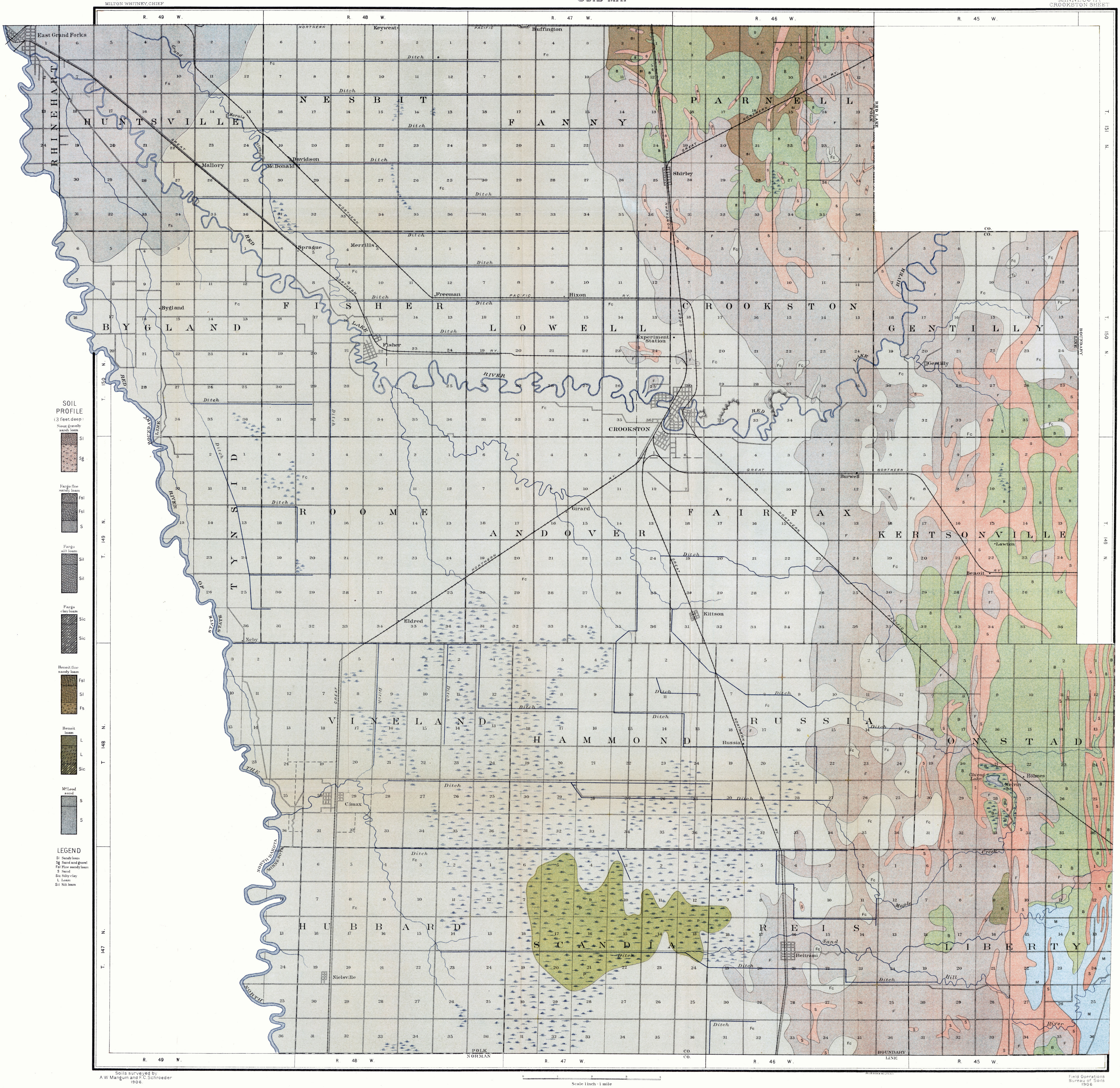
BUREAU OF SOILS
MILTON WHITNEY, CHIEF

SOIL MAP

MINNESOTA
CROOKSTON SHEET



Soils surveyed by
A.W. Mangum and F.C. Schroeder
1906

Scale 1 inch = 1 mile

Field Operations
Bureau of Soils
1906